Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2021

Program Name : B. Tech. (APE-Gas) **Semester : III**
Course Name : Air Fractionation and Purification of Gases **Time : 3 hr**
Course Code : CHGS 4002 **Max. Marks: 100**
Nos. of page(s) : 3

Instructions: Assume any missing data. The notations used here have the usual meanings. Draw the diagrams, wherever necessary.

SECTION - A (6 × 5 = 30 marks)
(Answer all the questions)

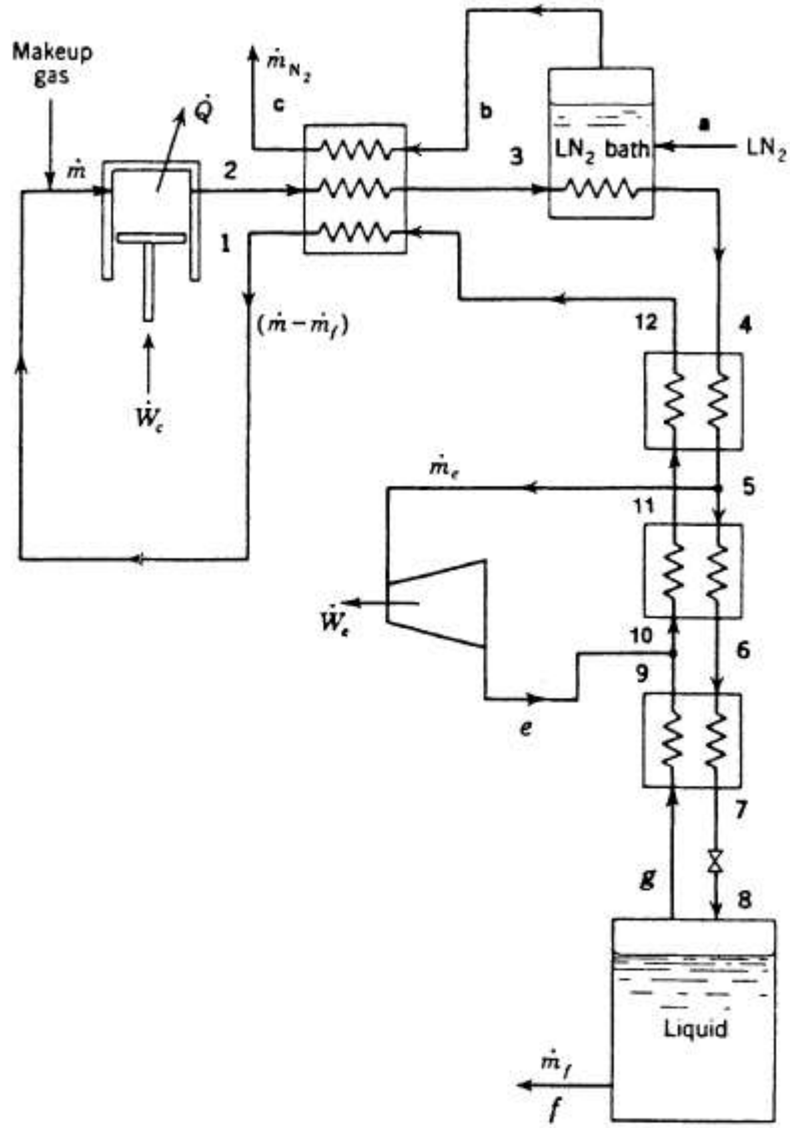
		Marks	CO
1.	Discuss the applications of Argon.	**5**	**CO1**
2.	Differentiate between the Linde and Claude cycle used for liquefaction	**5**	**CO3**
3.	What are the modifications suggested to improve the thermodynamic efficiency in Oxyton development?	**5**	**CO2**
4.	Differentiate between the food grade and nonfood grade carbon dioxide.	**5**	**CO1**
5.	What are the factors that affect the separation efficiency in case of membrane separation?	**5**	**CO4**
6.	Discuss the three factors affecting the optimum recovery of Argon in liquid plants.	**5**	**CO5**

SECTION - B (5 × 10 = 50 marks)
(Answer all the questions)

1.	Discuss the functions of the three operating control valves in the operation of a standard air separation plant.	**10**	**CO5**
2.	Define the Lachmann principle. Discuss the thermodynamic analysis of the Oxyton cycle.	**10**	**CO2**
3.	Discuss the recovery of carbon monoxide and hydrogen from partial oxidation of methane using a methane wash by absorption followed by fractionation.	**10**	**CO3**
4.	Discuss the separation of oxygen using vacuum pressure swing adsorption (VPSA).	**10**	**CO4**
5.	Explain the total recovery of helium from the natural gas with the help of a flow diagram.	**10**	**CO2**

SECTION – C (1 × 20 = 20 marks)
(Answer all the questions)

1.	A large hydrogen liquefaction plants uses a precooled Claude cycle with one expander similar to that shown in Fig.	**20**	**CO4**



This system could also be used as a refrigerator to cool helium gas. For the operating conditions shown below, determine the following:

(a) The liquefaction rate of parahydrogen when the system is used as a liquefier;
(b) The rate of liquid nitrogen consumption for the liquefier;
(c) The amount of helium gas (C_p = 2.5 R) that can be cooled from 25 to 20 K under steady-state conditions when the system is used as a refrigerator (assume that the helium behaves as an ideal gas at this temperature and pressure)
(d) The rate of liquid nitrogen consumption for the refrigerator in part (c).

Operating Conditions:

Parahydrogen compressed is **XXX** $\times 10^{-3}$ kg/s, where **XXX** is last three digits of SAP ID for both liquefier and refrigerator.
Temperatures of all streams on warm-side of three-channel heat exchanger are 293 K.
Compressor operates between 0.101 and 1.01 MPa.
Inlet temperature to expander is 60.8 K.

	70 % of parahydrogen diverted through expander. Assume ideality for expander, compressor, and heat exchangers. The liquid nitrogen bath operates at a pressure of 0.101 MPa. The thermodynamic properties for parahydrogen are as follows: h (0.l01 MPa, 293 K) = 4100 kJ/kg S (0.l01 MPa, 293 K) = 64.5 kJ/kg-K h (1.01 MPa, 293 K) = 4100 kJ/kg S(1.01 MPa, 293 K) = 55 kJ/kg-K h (1.01 MPa, 77.3 K) = 780 kJ/kg h (1.01 MPa, 60.8 K) = 590 kJ/kg S(1.01 MPa, 60.8 K) = 32 kJ/kg K h (0.l0l MPa, 77.3 K) = 808 kJ/kg h (0.l01 MPa, 20.4 K) = -256 kJ/kg S(0.101 MPa, 20.4 K) = 8 kJ/kg-K h (0.101 MPa, 77.3 K) = 29 kJ/kg h (0.10l MPa, 293 K) = 455 kJ/kg For an ideal expander S_e = 32kJ/kg-K at 0.101 MPa, h_e=235kJ/kg.		